ASEN-6519 Lidar Remote Sensing
Lecture 01. Introduction of Lidar Class

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LIDAR: What and Why?

LIDAR stands for Light Detection and Ranging, commonly known as Laser Radar.

Lidar is not only replacing conventional sensors, but also creating new methods with unique properties that could not be achieved before.

Lidar is extremely useful in atmospheric and environmental research as well as space exploration. It also has wide applications in industry, defense, and military.
LIDAR: Light Detection And Ranging

- Send light to the atmosphere
- Record light scattered by the atmosphere as function of time
- Convert time of flight to distance (1 ms ~ 150 km)
Lidar from Ground to Space

<table>
<thead>
<tr>
<th>Program Carrier</th>
<th>Circa</th>
<th>Channels</th>
<th>Laser(s) (*tunable)</th>
<th>Measurement of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND. based, 48 inch</td>
<td>1970</td>
<td>2</td>
<td>Ruby @ 347 &amp; 694 nm</td>
<td>Aerosols/N₂</td>
</tr>
<tr>
<td>Aircraft Electra 390</td>
<td>1978</td>
<td>3</td>
<td>Ruby, YAG, YAG/Dye @ 1064, 720*, 694, 600*, 532, 347, 300* nm</td>
<td>Aerosols H₂O/O₃</td>
</tr>
<tr>
<td>LASE, ER 2</td>
<td>1994</td>
<td>3</td>
<td>Ti: Al₂O₃ @ 815 nm</td>
<td>H₂O/Aerosols</td>
</tr>
<tr>
<td>LITE, Shuttle</td>
<td>1994</td>
<td>3</td>
<td>YAG @ 1064, 532. 355 nm</td>
<td>Aerosols/clouds Density</td>
</tr>
<tr>
<td>ESSF</td>
<td>TBD</td>
<td>3</td>
<td>YAG @ 1064, 532</td>
<td>Aerosols/clouds</td>
</tr>
</tbody>
</table>
Coincident Observations from PICASSO-CENA, CloudSat and EOS-PM address the role of clouds and aerosols in the Earth radiation budget.
CALIPSO: Lidar on Satellite

http://www-calipso.larc.nasa.gov/
Aqua (A) Train for Multiple Observations

A-train - A group of Instruments with complementary sensor capability flying in a satellite formation in order to observe the same atmosphere – OCO now added
NOAA ESRL Lidars on Ocean

- Mini-MOPA
- HRDL
- OPAL
- TOPAZ
- DABUL
- Fish Lidars
- TUV
- CODI
- TEAC0
- ABAeL
Basic Lidar measurements

- Chemical distributions (ozone, water vapor, NH3, CO2)
- Cloud properties
- Aerosol measurements
- Low level mean winds
- Residual winds
- Turbulence, general dynamics

Instruments have been mounted on research ships for sea based operation

Challenges include:
- Sea salt corrosive environment
- High vibration
- Platform motion & orientation
- Low frequency accelerations – stability issues
- Big waves and leaky seatainers
mini-MOPA Lidar
The Atmosphere and the Earth-Space Interface

Ionized F-layer

Reflected short wave radio signals

Shuttle

Ionized E-layer

Northern lights

Rocket

Ionized D-layer

Meteorites

Spy plane

Weather balloon

Mt. Everest

Jet

Clouds
NSF/NCAR Electra Aircraft

Airborne Fe Boltzmann Lidar
Groundbased Lidar at the South Pole
Containerized Lidar at Rothera, Antarctica
Containerized Lidar at Svalbard
Andoya Rayleigh & Na Lidars
Sondrestrom Rayleigh Lidar
Large-Aperture Na Doppler Lidar at SOR, NM and Maui, HI
Arecibo Observatory K Doppler Lidar
Why Lidar Course?

This 6000 level class is based on the previous 5000 level "Laser Remote Sensing" class offered in Spring 2006.

But it has been significantly upgraded to include more lidar examples, lidar data processing projects, and lidar design components.

Students will be offered field-trip opportunities to CSU Fort Collins lidar facility.

Guest speakers will be invited from different lidar groups.
Lidar Course Objectives

1. A comprehensive, yet easily understandable, up-to-date overview of lidar principles, technologies, and applications;

2. Practice of lidar data retrieval, lidar system design, and quantitative analysis of lidar performance and measurement errors;

3. Opportunities to see and possibly operate the real state-of-the-art lidar systems and make connections to lidar experts in the nation and world.
Textbook and Reading Materials

Textbook:
edited by Fujii and Fukuchi

Major Reference Books:
“Lidar” (2005)
edited by C. Weitkamp
by Raymond Measures

Reading Materials will be posted on the webpage.
Course Format

1. PPT presentation in classroom

2. Lecture notes posted at the class webpage:
   http://cires.colorado.edu/science/groups/chu/classes/

3. Reading books and materials with reports

4. Projects as homework with presentations in class

5. Field Trip to CSU, NOAA and/or NCAR

6. Guest lectures
How to study this course?

1. Read books and lecture notes prior to classes, especially if lack of background
2. Listen to the lectures and try to understand the most in classes
3. Review lecture notes and read books and materials
4. Do projects to apply learned skills and check concepts
5. Ask and discuss with instructor and classmates to get clear concepts
6. Visit instructor’s research group to look at real instruments and real applications
Grading Policy

10% Reading Reports: your understanding to lidar principles, technologies, and applications

80% Projects:
(1) Data retrieval and error analysis (e.g., Na density, Doppler temp and wind, Boltzmann and Rayleigh temperature, coherent wind, HSRL aerosol, edge filter wind, DIAL, or Raman lidar data)
(2) Lidar design and performance analysis
(3) Lidar simulation tools

10% Presentations: your results from projects and presentation skills

100-point grading system for each report, project, and presentation
Office Hours in Spring 2007

Lectures: M. W. F.  2:00-2:50pm @ MUEN D439

Office hours: Wed. 3:00-5:00pm
and stop by office at any time

@ CIRES 241 or 1B49

Questions regarding
lecture contents & projects & other lidar related
Guest Lecture --
Prof. Chiao-Yao She (CSU)
Guest Lecture --

Dr. Sara Tucker (NOAA)
Guest Lecture --

Dr. Carl Weimer (Ball Aerospace)
CRRL: Consortium of Resonance and Rayleigh Lidars

Lidar Consortium Technology Center

Community Center for Excellence

http://crrl.colorado.edu/

http://crrl.colorado.edu/phpBB2/

Good projects will be used at the CTC website!!!
Pole-to-Pole Expedition

21 June 1999
Over the North Pole

24 November 1999
At the South Pole
I was flying the Electra, right above the North Pole!
Pole-to-Pole Expedition: South Pole

Amundsen-Scott South Pole Station
Summary

We expect an exciting adventure through the wonderful “lidar remote sensing” field ...

Hope you will stay with us in the journey ...

Let us work together to make advancement and contribution to lidar and lidar application.